2nd AIAA Drag Prediction Workshop Results Using NES

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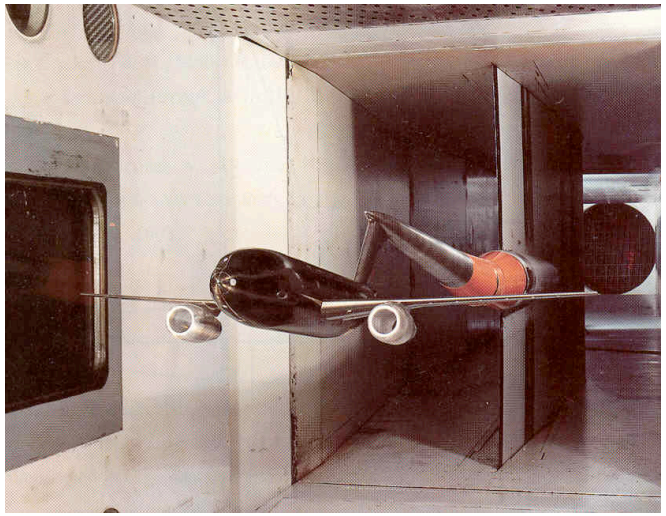


DLR – F6
M=0.75
Re_cref=3 million

NES CODE GENERAL DESCRIPTION

- Reynolds-averaged Navier-Stokes solver for 3D geometries
- Spalart-Allmaras & Baldwin-Lomax turbulence models
- Multiblock / Multiface structured grid
- High accuracy ENO scheme free of artificial viscosity
- Multigrid approach with defect correction for robust speed-up
- High Parallel Efficiency on cluster of Pentium 1000Mhz
- Interface to graphical postprocessor OMNI3D™ (Analytical Methods,Inc.)

SOLVER INFORMATION

Method Name:	**NES Multiblock Structured Navier-Stokes Solver**
Basic Algorithm:	**Multigrid FAS + ENO Defect Correction**
Turbulence Model:	**Spalart-Allmaras**
Miscellaneous:	**No tuning parameters !**

GRID INFORMATION

Grid-Generator Name:	ICEM-CFD	
Grid Type:	Structured Multiblock Point-to-Point Grids	
COARSE GRID SIZE	**WB (0.5M)**	**WBNP (1.3M)**
Zones:	73	228
Field Cells:	467120	1215920
MEDIUM GRID SIZE	**WB (4M)**	**WBNP (10.4M)**
Zones:	73	228
Field Cells:	3736960	9727360

SOLUTION INFORMATION

Computer Platform:

1. Linux PC's Multiprocessors cluster of HP Netserver LP1000R 1GHz
2. 142 CPU - Processor Pentium 3 - 2GB RAM
3. Full duplex 100Mbps ETHERNET interface
4. MOSIX software package enhances the LINUX kernel with cluster computing capabilities

Operating System: Linux + MOSIX + PVM

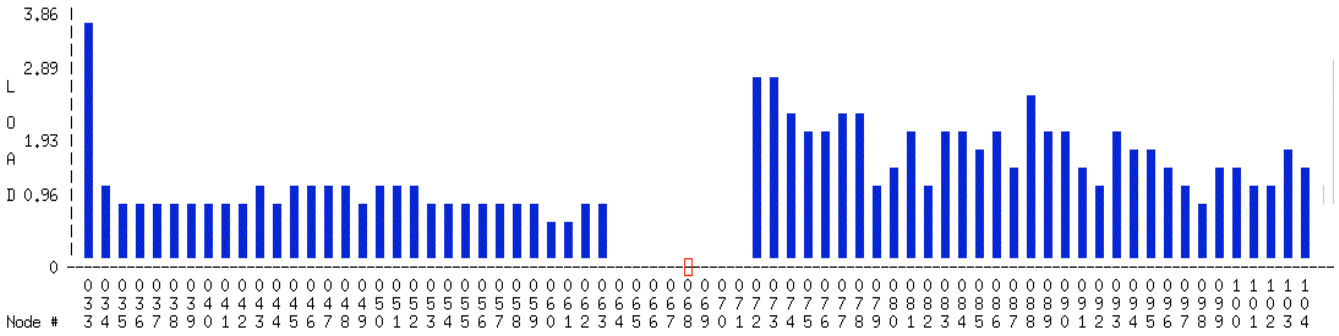
Compiler: C

Run Time Wall-Clock: **WB 4M=2days on 60 Processors**

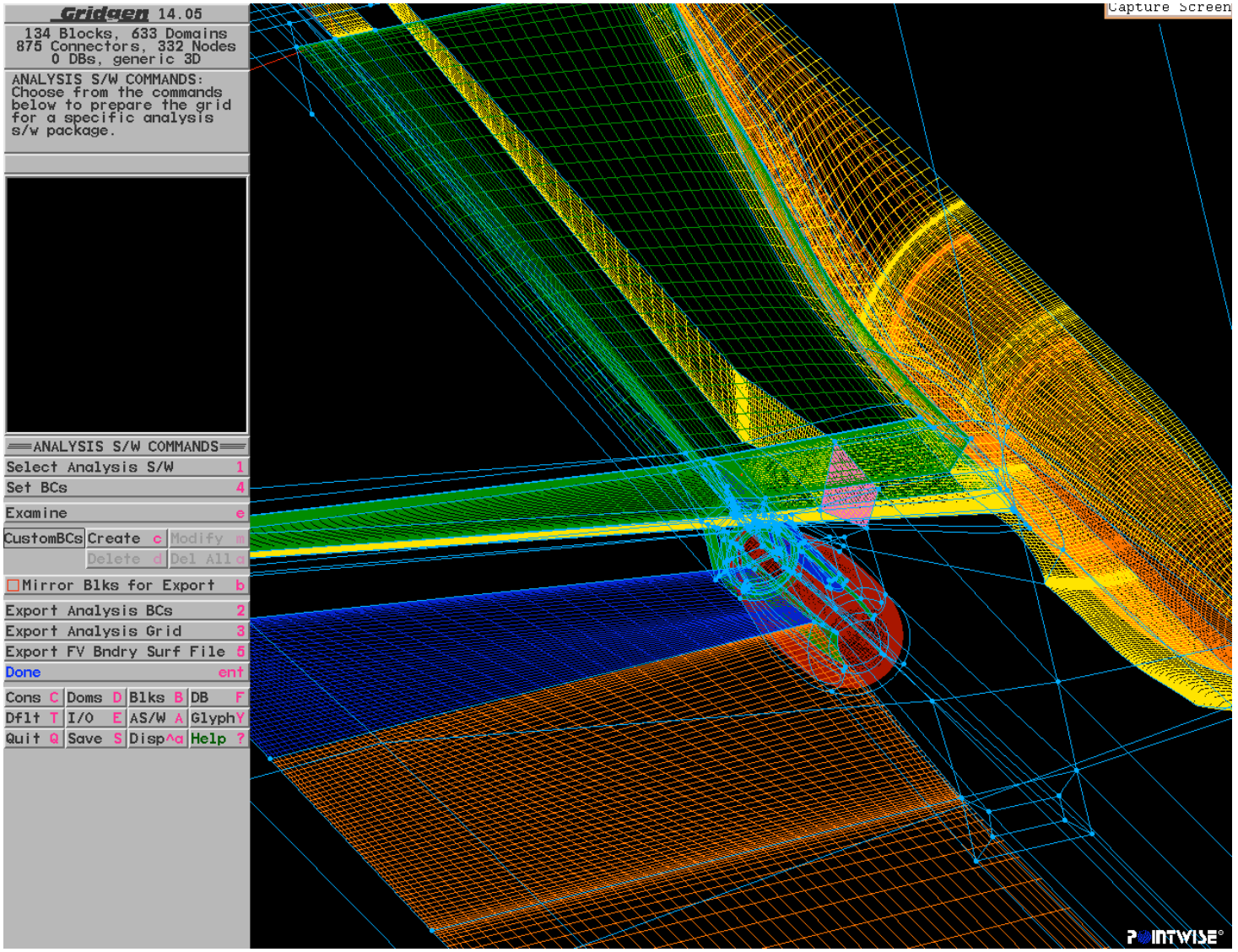
WBNP 10.4M=2days+17hours on 142 Processors

Memory Requirements: **WB 4M ~224MB per processor Total 1.3GB RAM**

WBNP 10.4M ~ 240MB per processor Total 3.5GB RAM



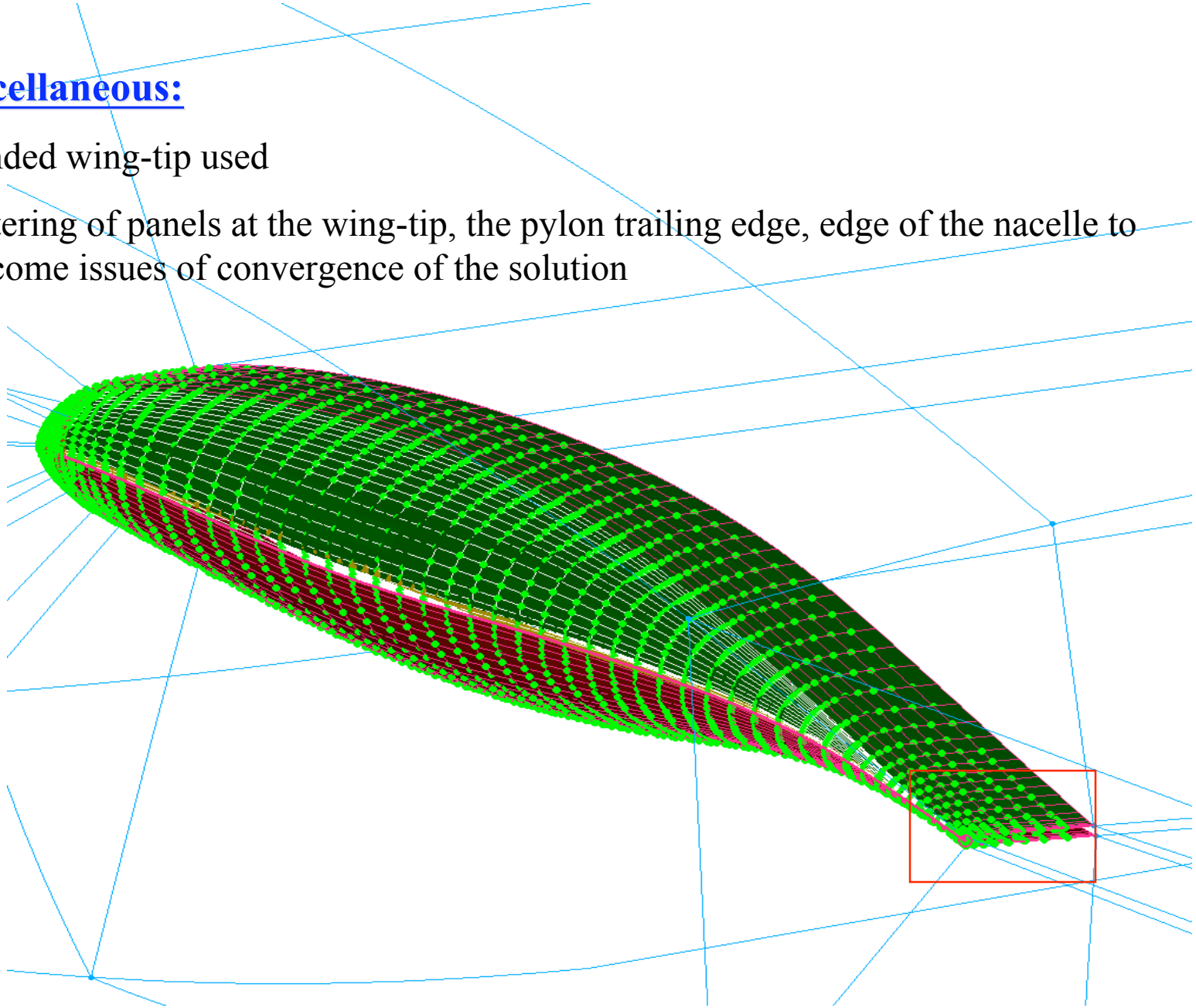
Split of original grid to allow one type of BC per block face

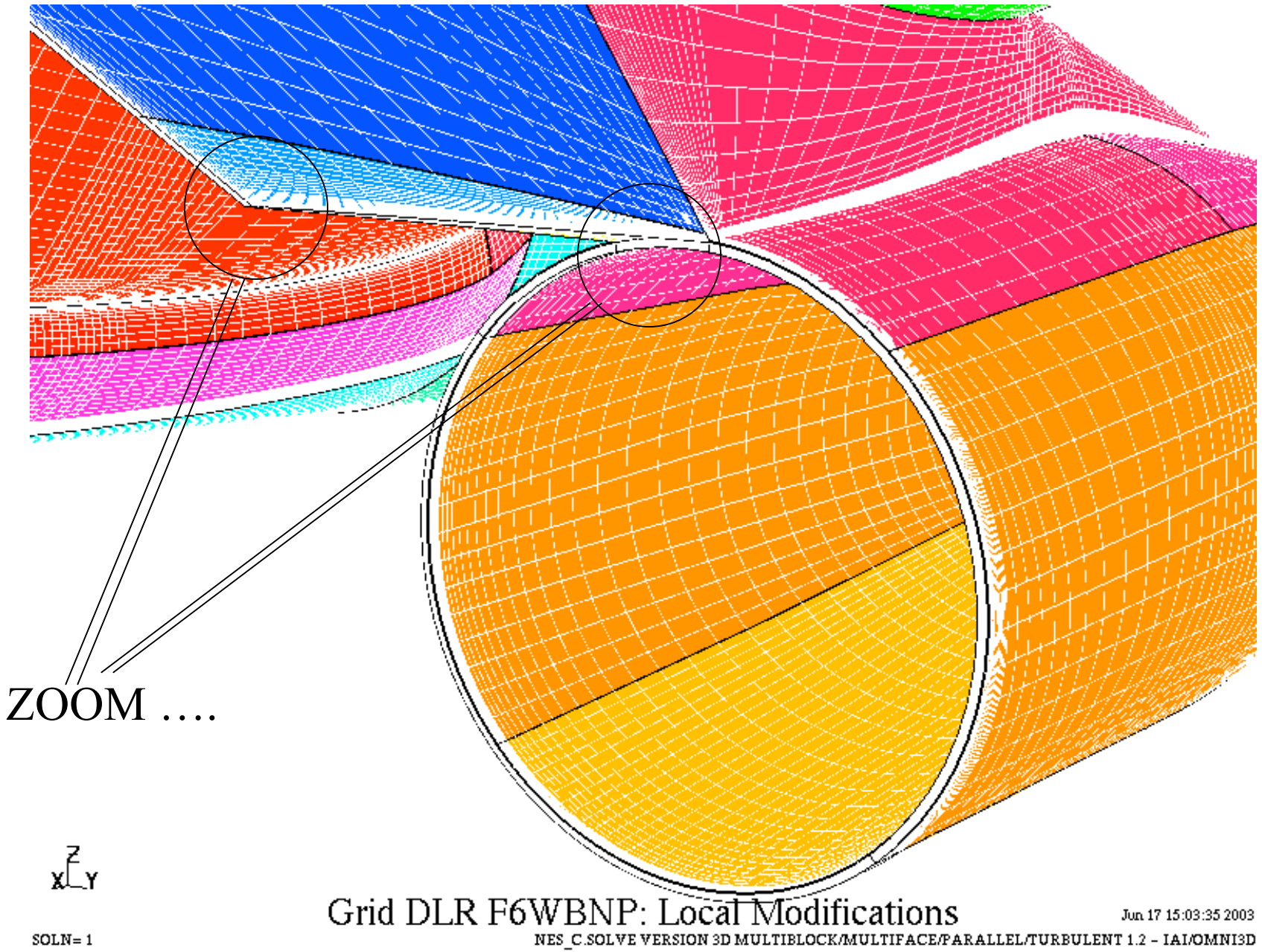


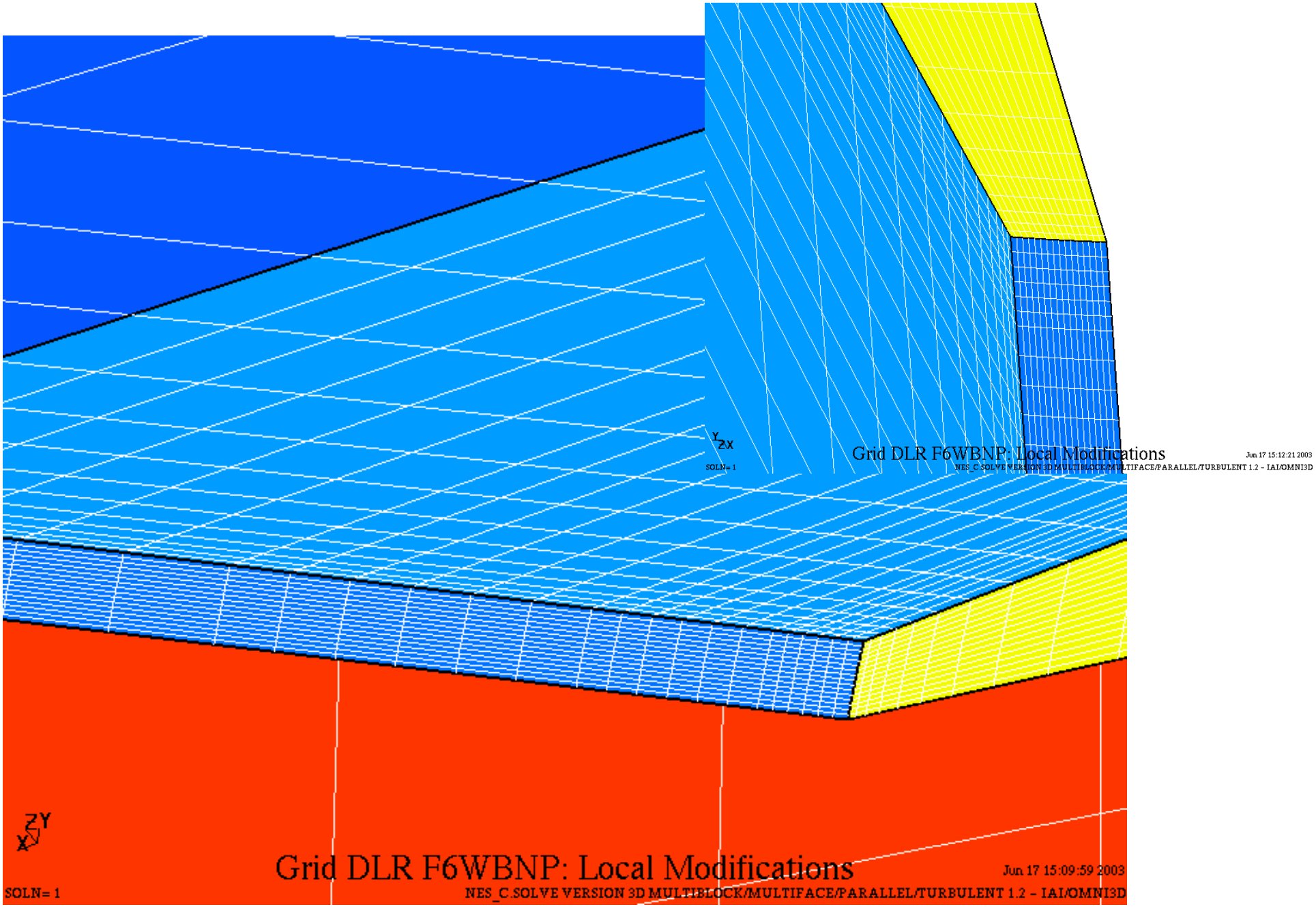
Miscellaneous:

Rounded wing-tip used

Clustering of panels at the wing-tip, the pylon trailing edge, edge of the nacelle to overcome issues of convergence of the solution




ZOOM ….
Z
X
Y
Grid DLR F6WBNP: Local Modifications
Jun 17 15:03:35 2003
SOLN= 1
NES_C.SOLVE VERSION 3D MULTIBLOCK/MULTIFACE/PARALLEL/TURBULENT 1.2 - IAI/OMNI3D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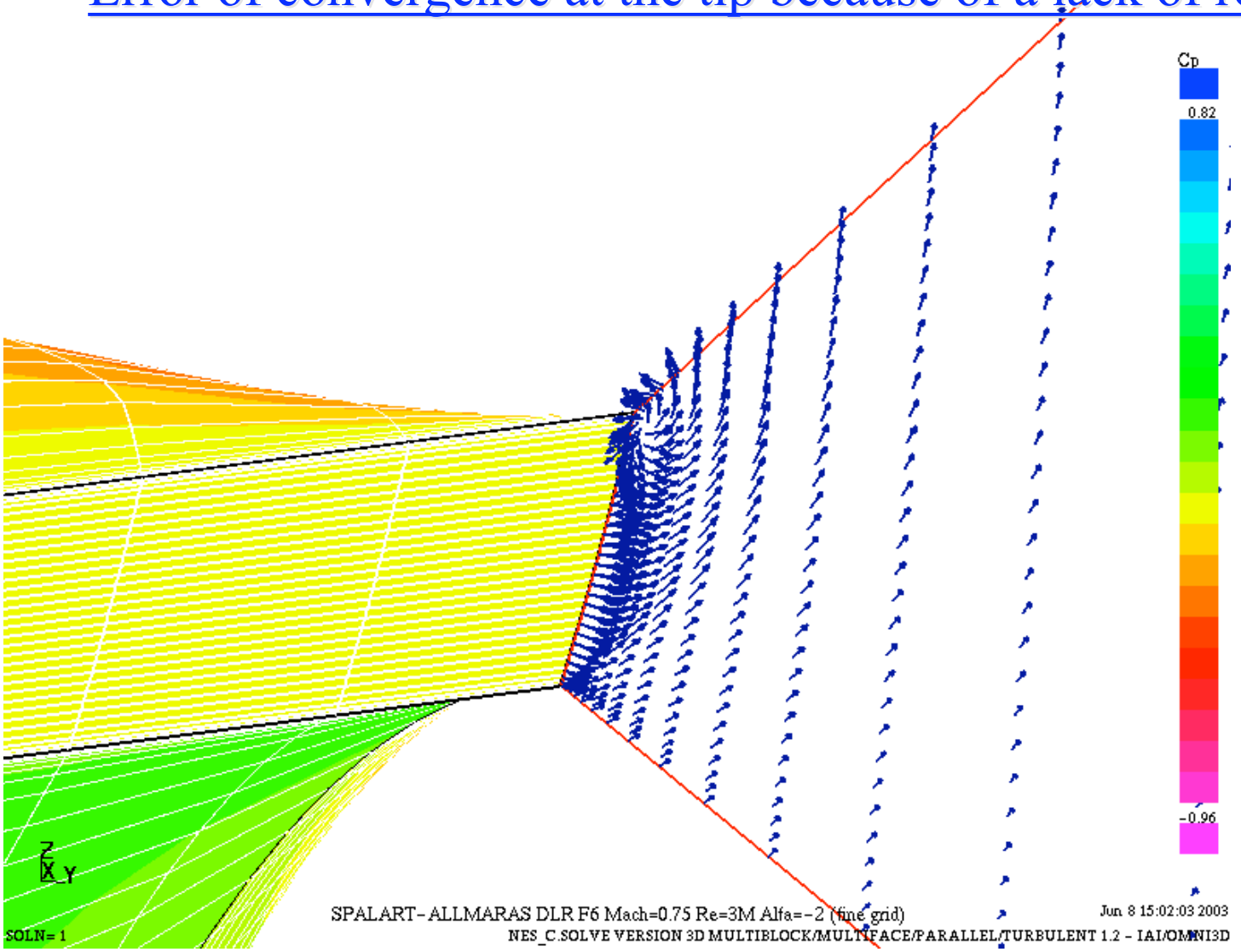
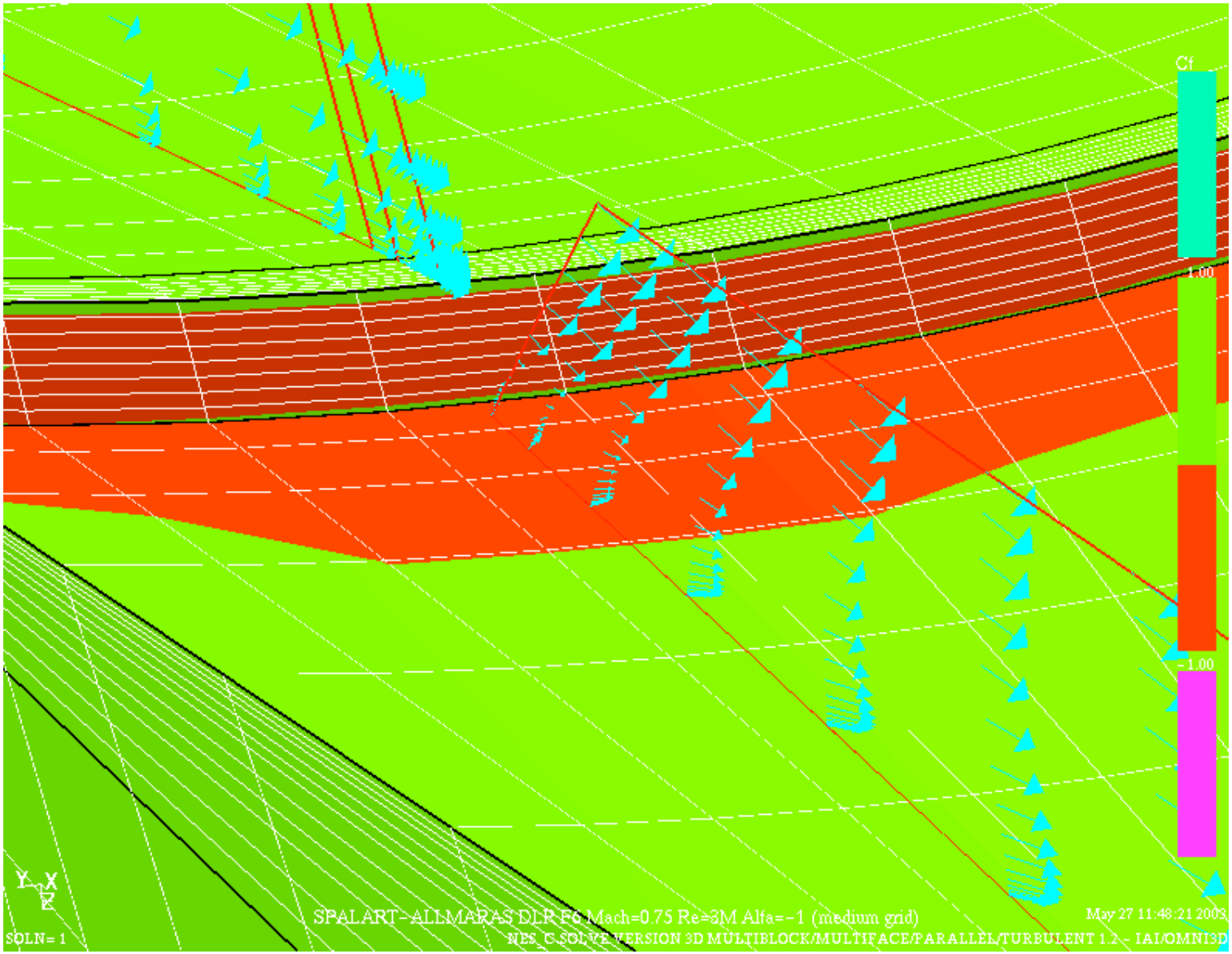
SOLN= 1
Grid DLR F6WBNP: Local Modifications
Jun 17 15:09:59 2003
NES_C.SOLVE VERSION 3D MULTIBLOCK/MULTIFACE/PARALLEL/TURBULENT 1.2 - IAI/OMNI3D
SOLN= 1

Error of convergence at the tip because of a lack of resolution

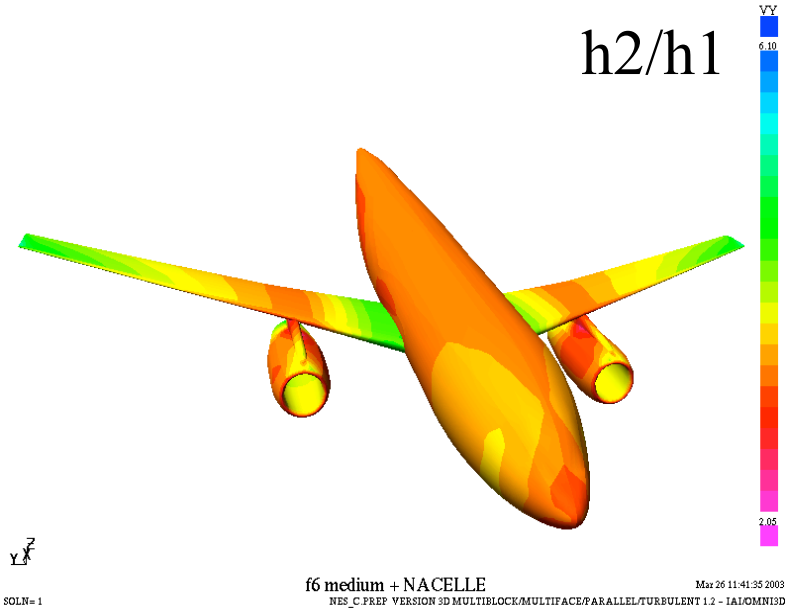


Backward-facing step flow configuration: after clustering

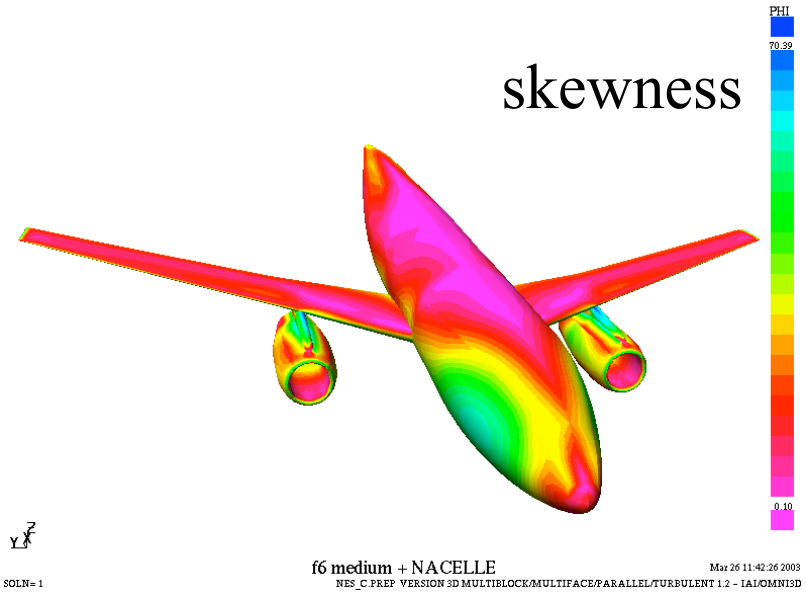


Preprocessor control of grid quality

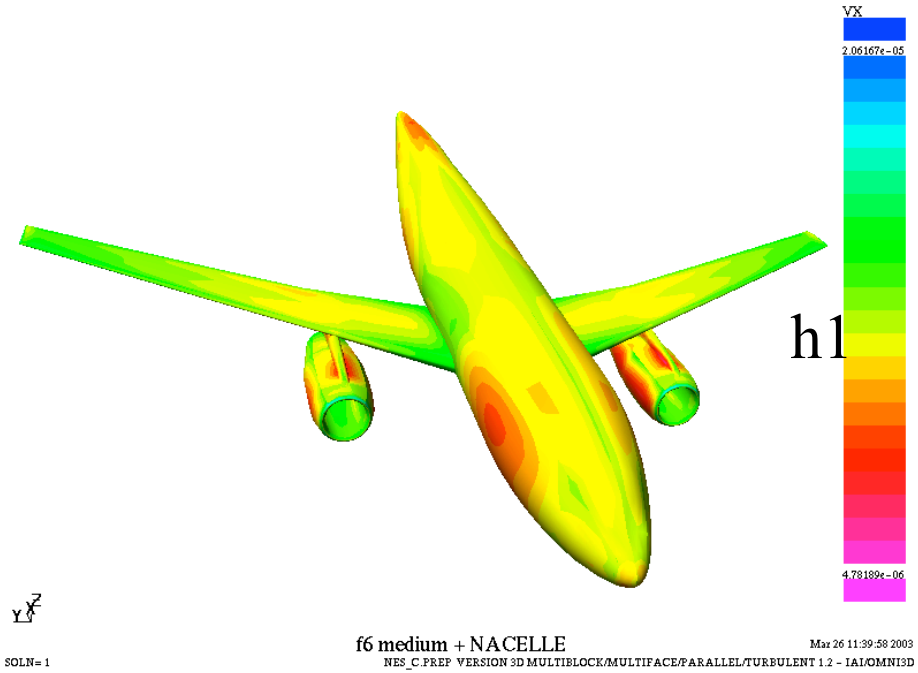
h2/h1



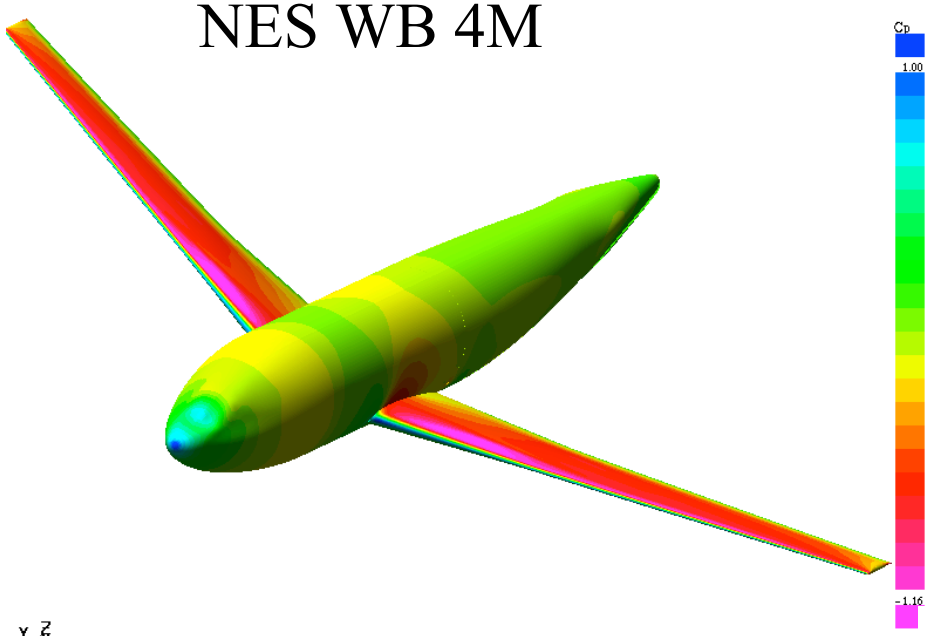
skewness



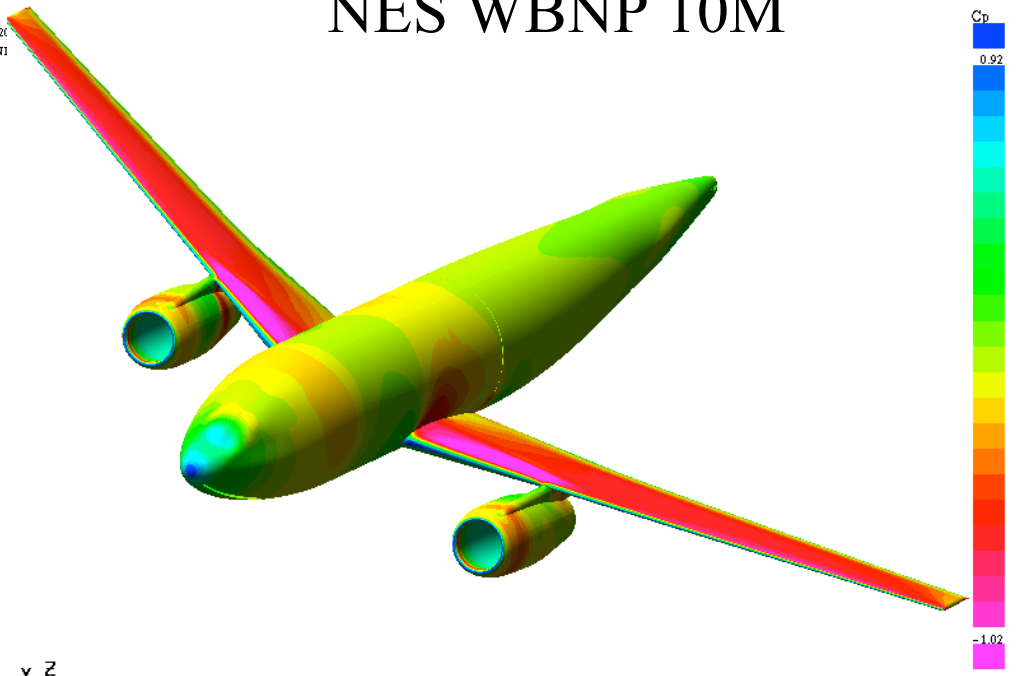
h1



NES WB 4M



NES WBNP 10M



Wing-body-nacelle-pylon - wing section 2y/b=0.15
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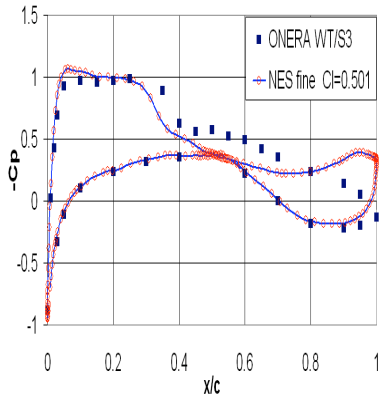

Wing-body-nacelle-pylon - wing section 2y/b=0.239
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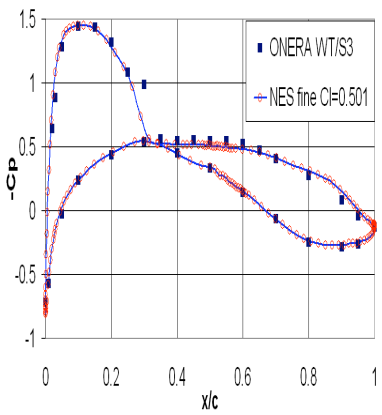

Wing-body-nacelle-pylon - wing section 2y/b=0.331
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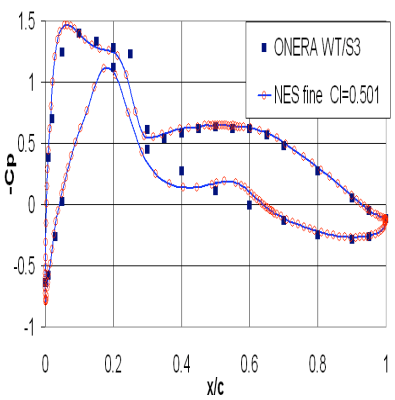

Wing-body-nacelle-pylon - wing section 2y/b=0.377
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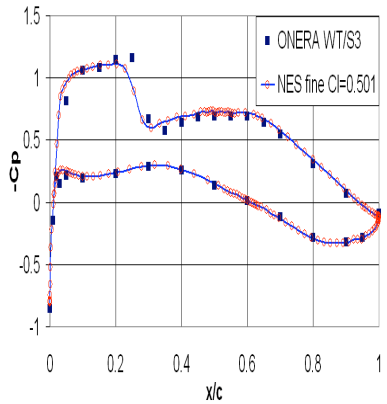
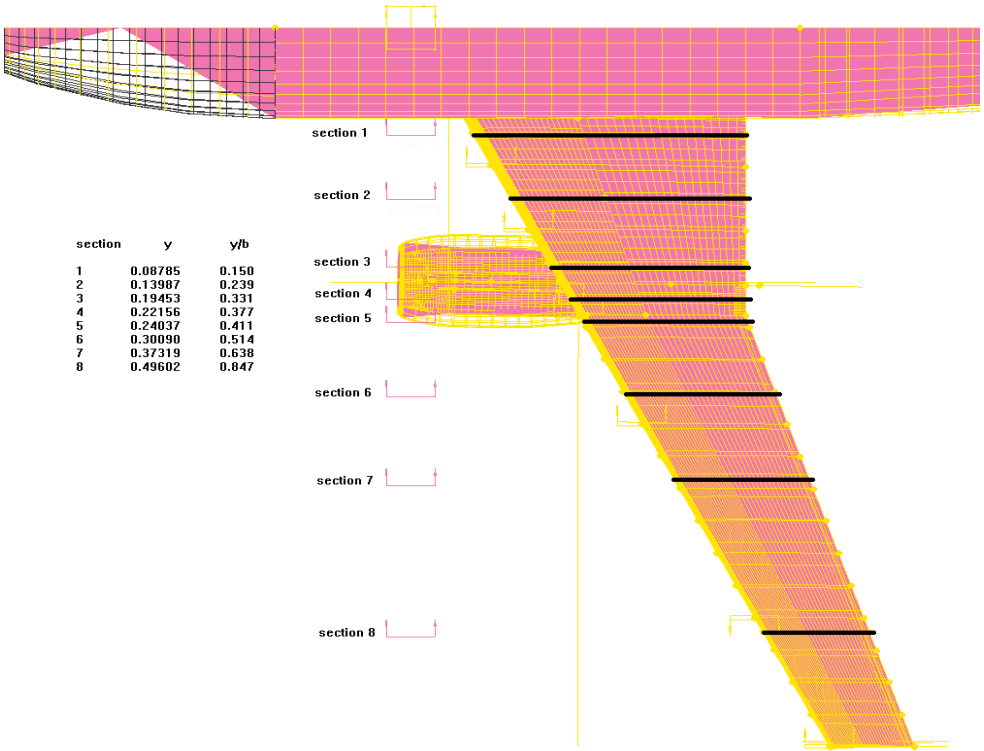
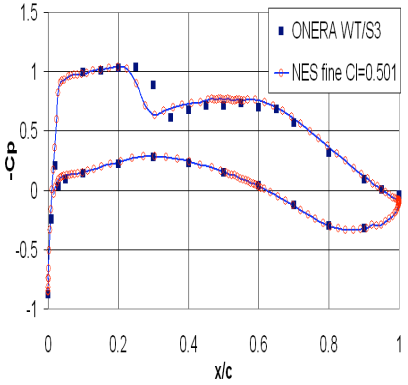




section	y	y/b
1	0.08785	0.150
2	0.13987	0.239
3	0.19453	0.331
4	0.22156	0.377
5	0.24037	0.411
6	0.30090	0.514
7	0.37319	0.638
8	0.49602	0.847

Wing-body-nacelle-pylon - wing section 2y/b=0.411
CL_exp=0.4981



Wing-body-nacelle-pylon - wing section 2y/b=0.514
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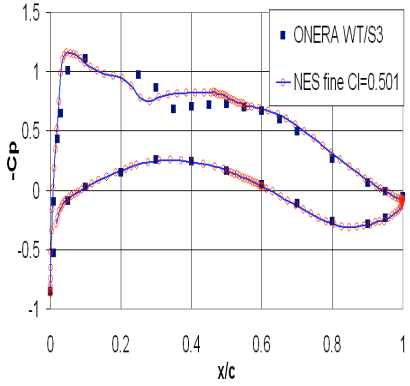

Wing-body-nacelle-pylon - wing section 2y/b=0.638
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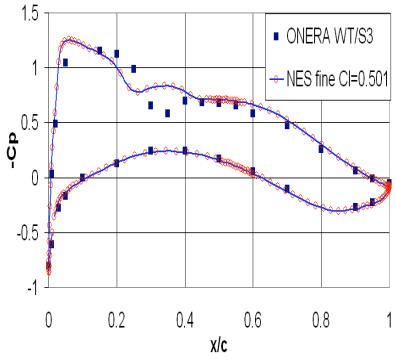

Wing-body-nacelle-pylon - wing section 2y/b=0.847
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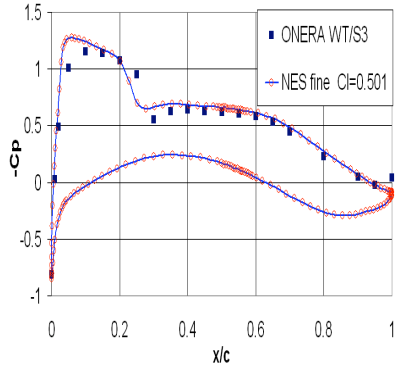
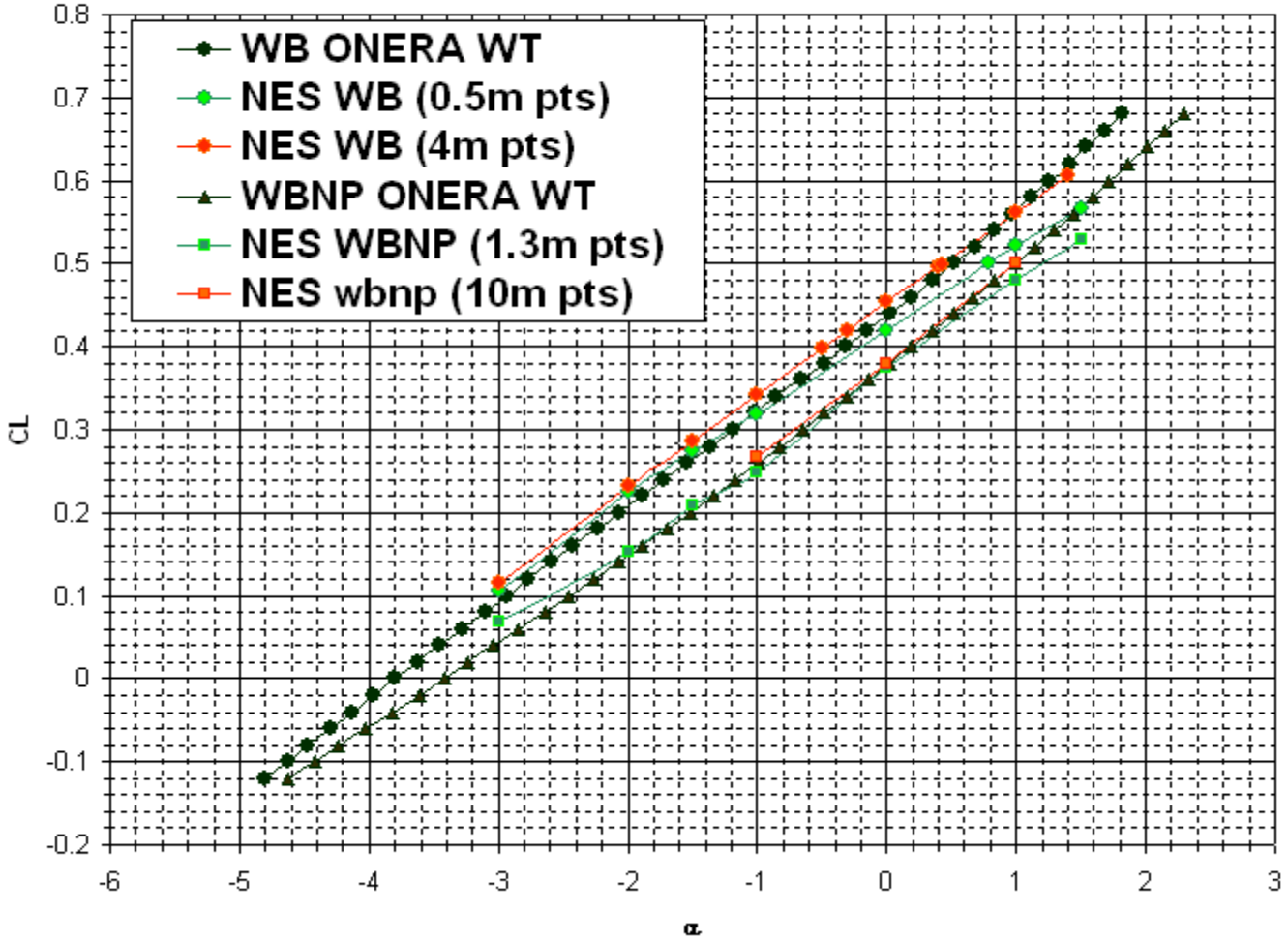


2nd AIAA DRAG PREDICTION WORKSHOP- JUNE 2003

LIFT VERSUS AoA - DLR_F6 (NACELLE ON/OFF)



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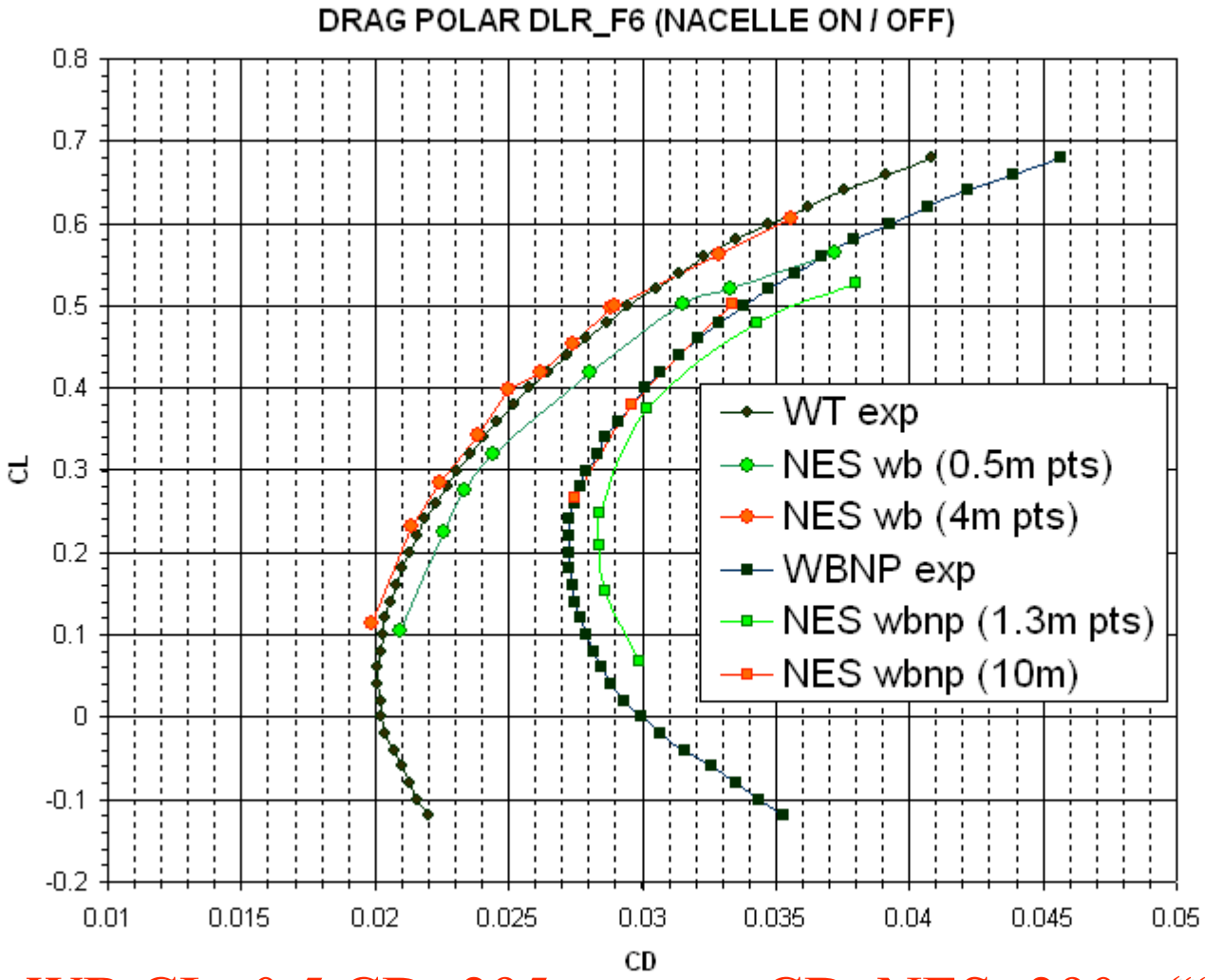

Exp. WB CL=0.5 CD=295c CD_NES=290c (“medium” grid 4M)

Exp. WBNP CL=0.5 CD=338c CD_NES=334c (“medium” grid 10M)

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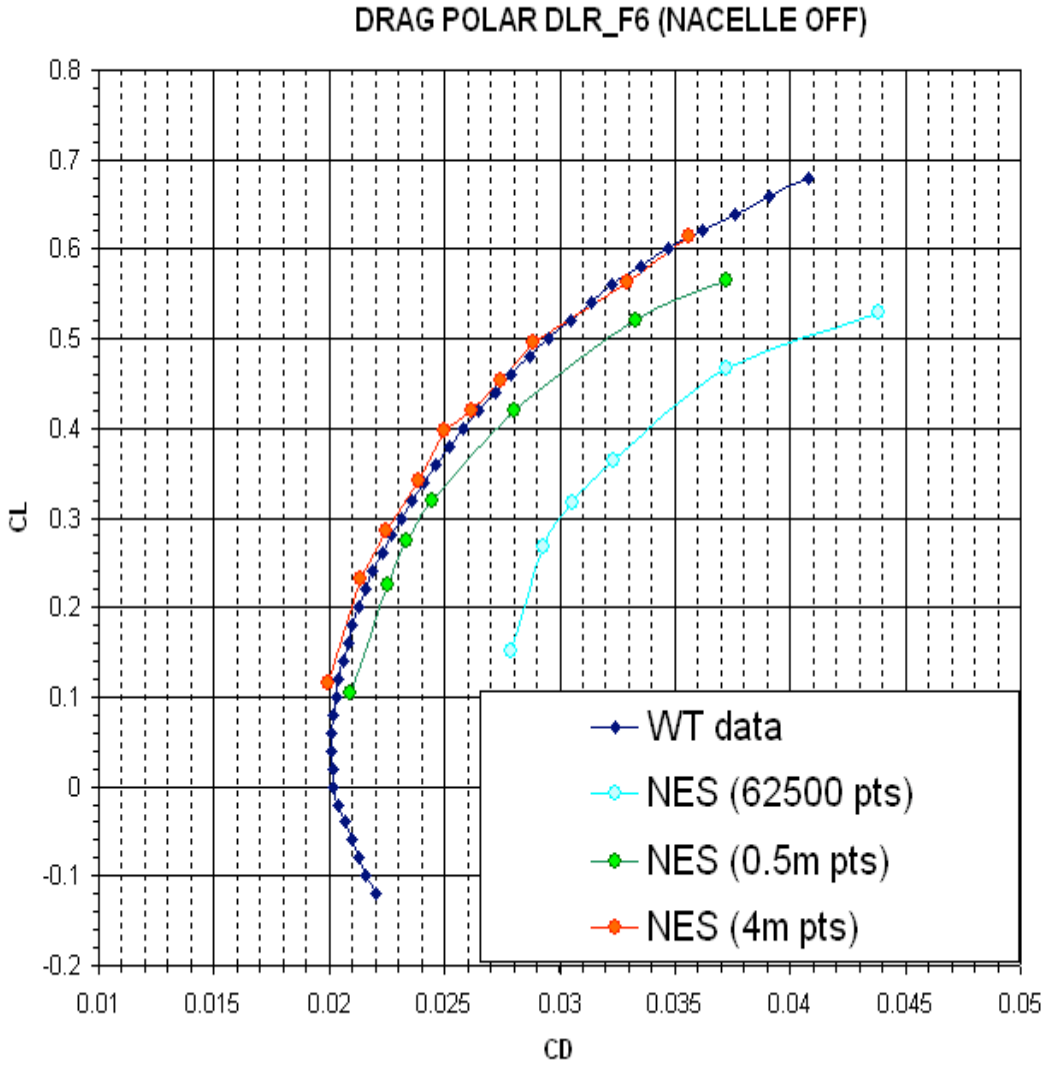
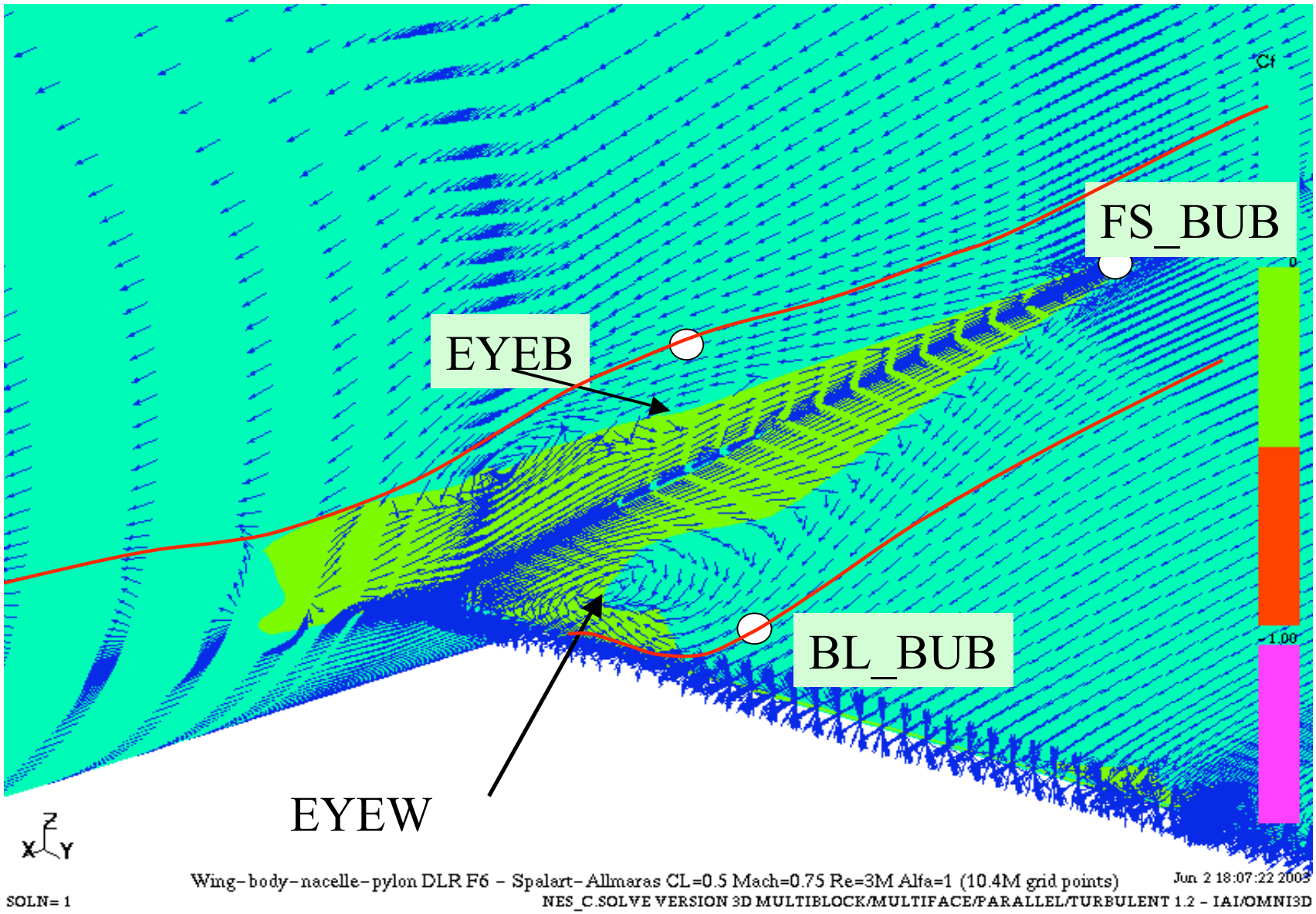
GRID CONVERGENCE

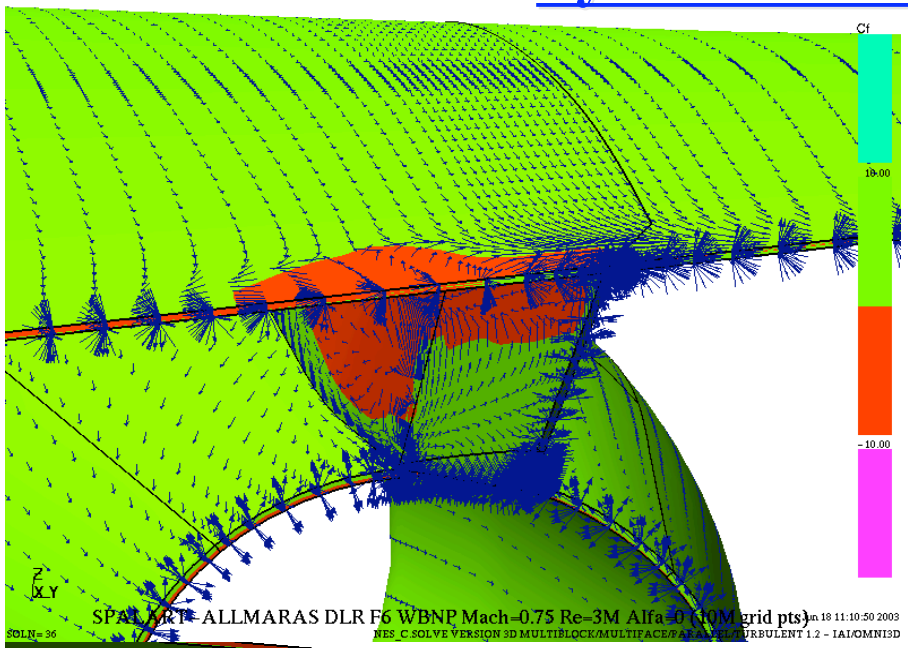
2nd AIAA DRAG PREDICTION WORKSHOP - JUNE 2003

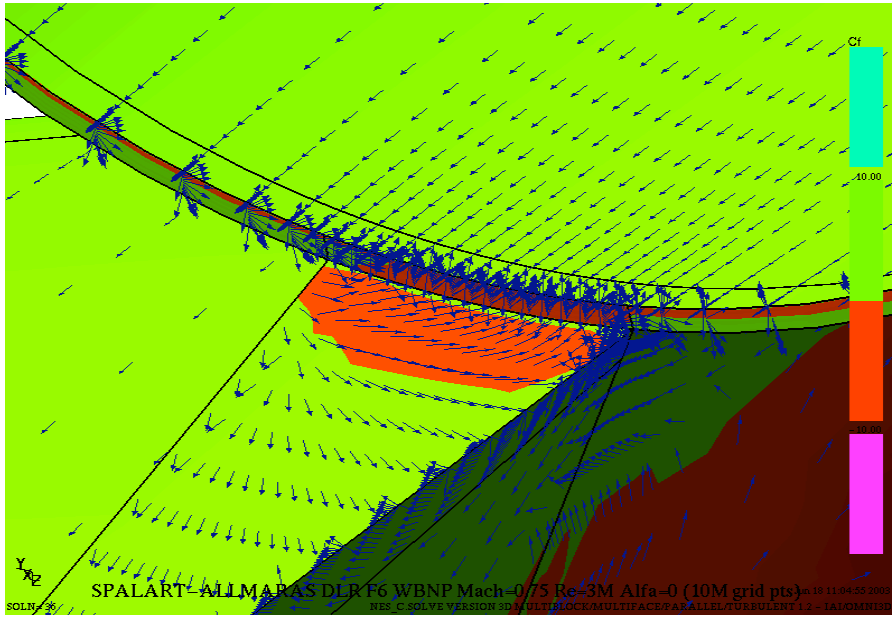


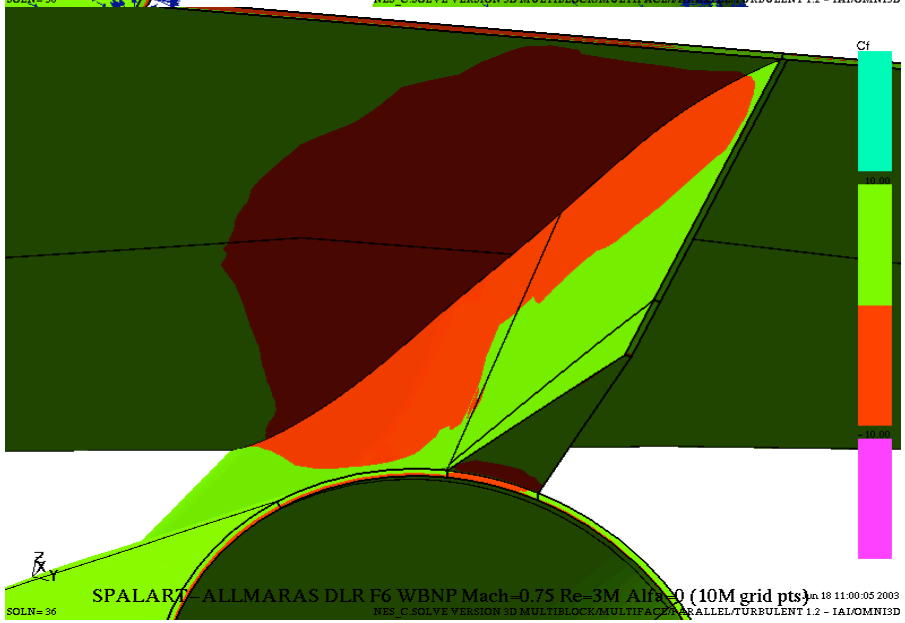
Wing-body junction: Bubble area (qualitative description)

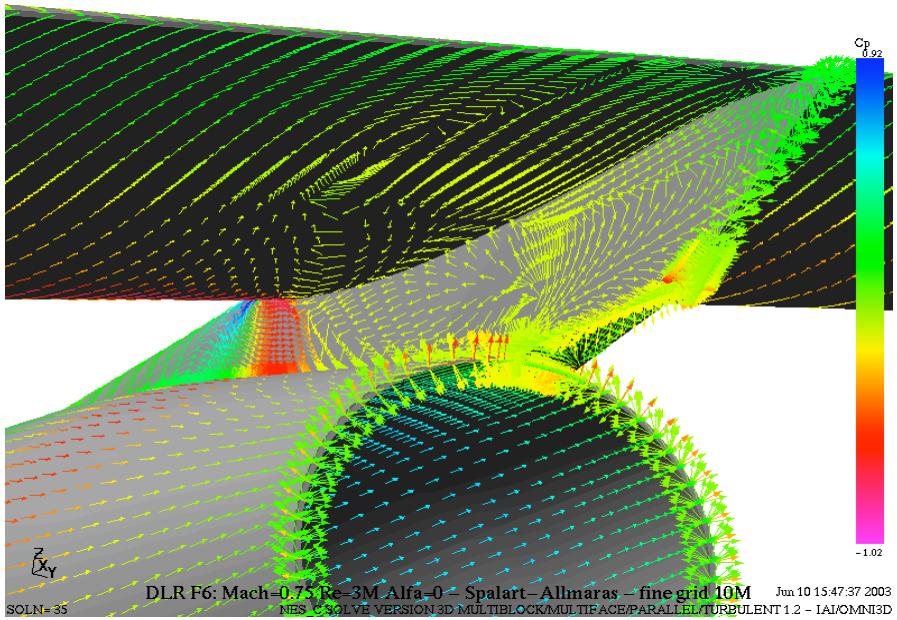


Pylon-nacelle reverse flow areas









CONCLUSIONS

- on the basis of comparison with experiment good accuracy has been presented already on relative coarse grids

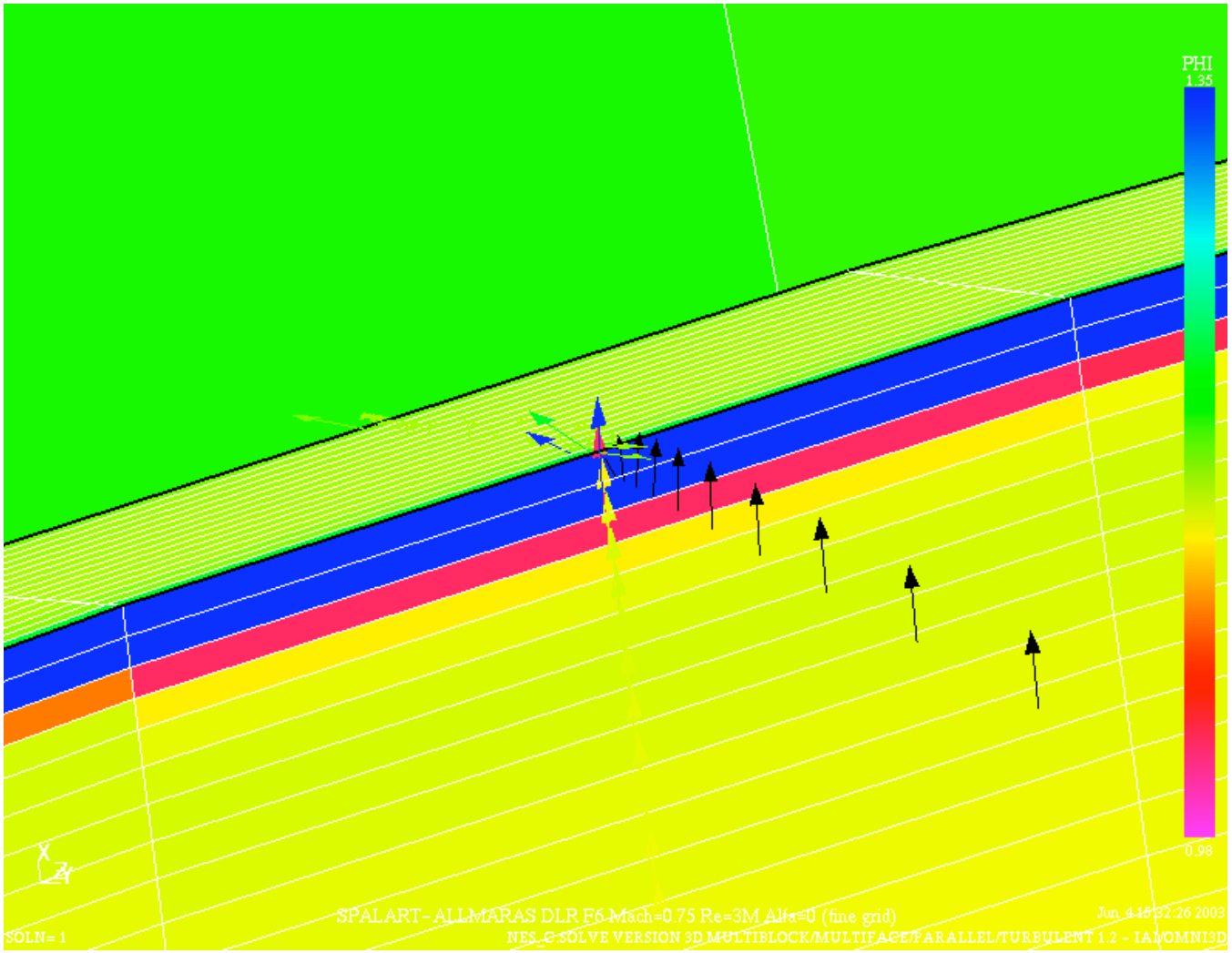
- formally proof of grid convergence is not presently demonstrated

- according to our current experience using NES vith various configurations we do not expect that the provided fine grid would significantly change the results

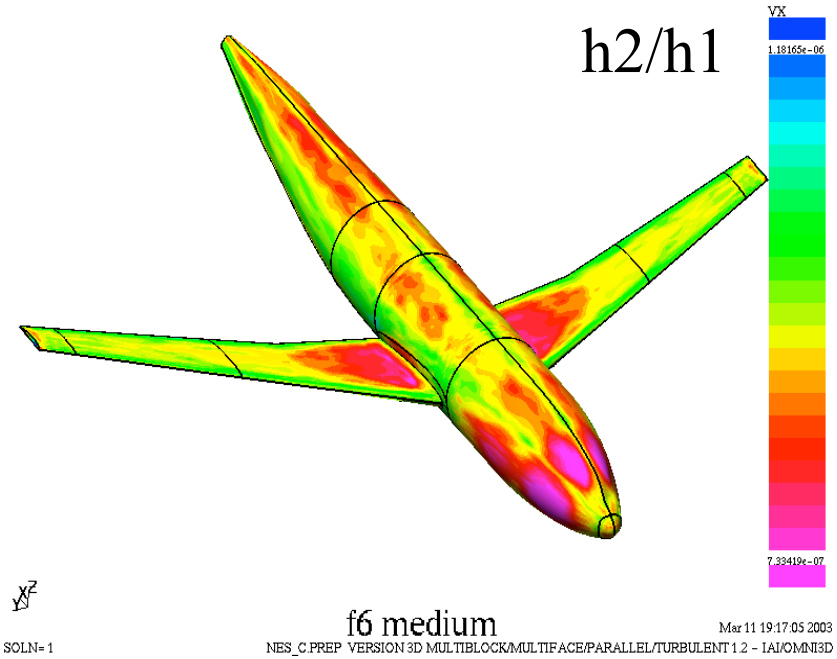
- some geometry areas (corners, steps, tip, pylon) need better grid resolution than in the baseline grid

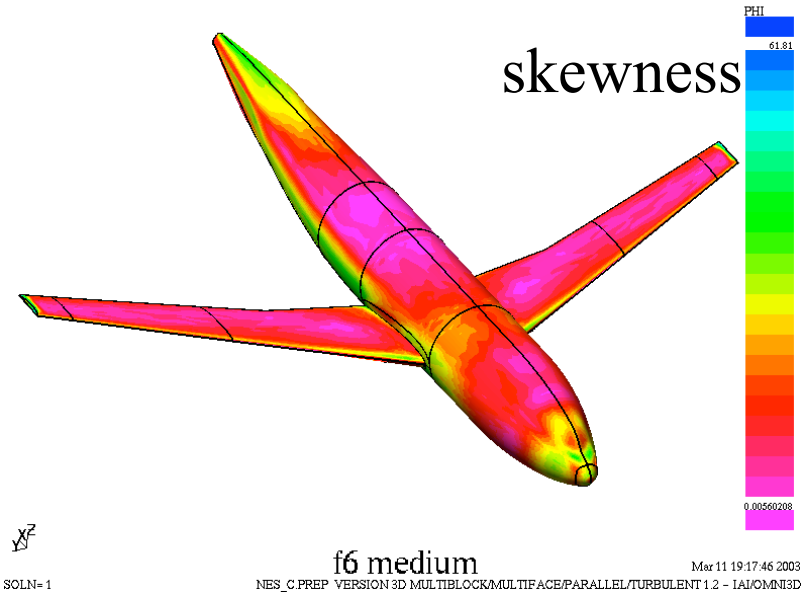
Error of convergence at the nacelle backward-facing step

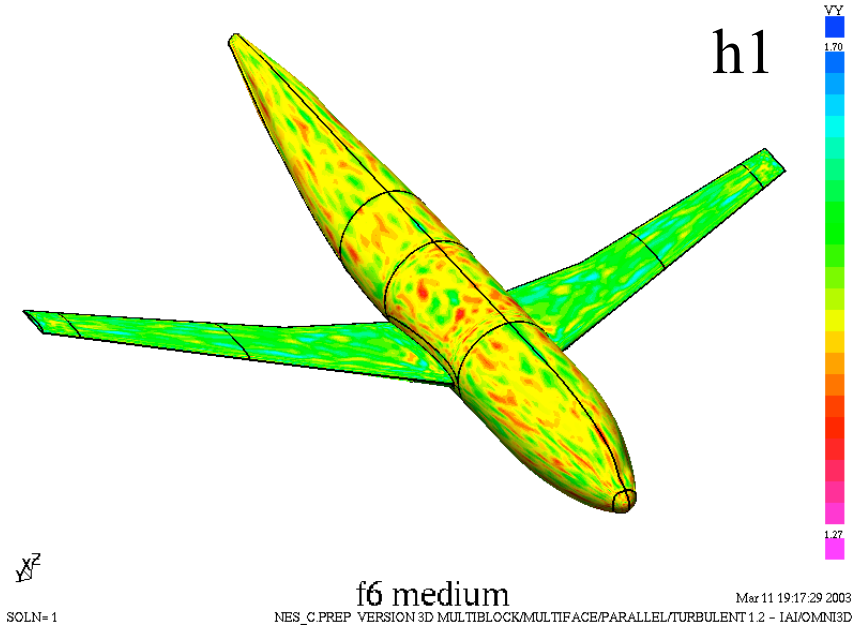
Control of problem in the solution convergence with the SA turbulent index



Preprocessor control of grid quality



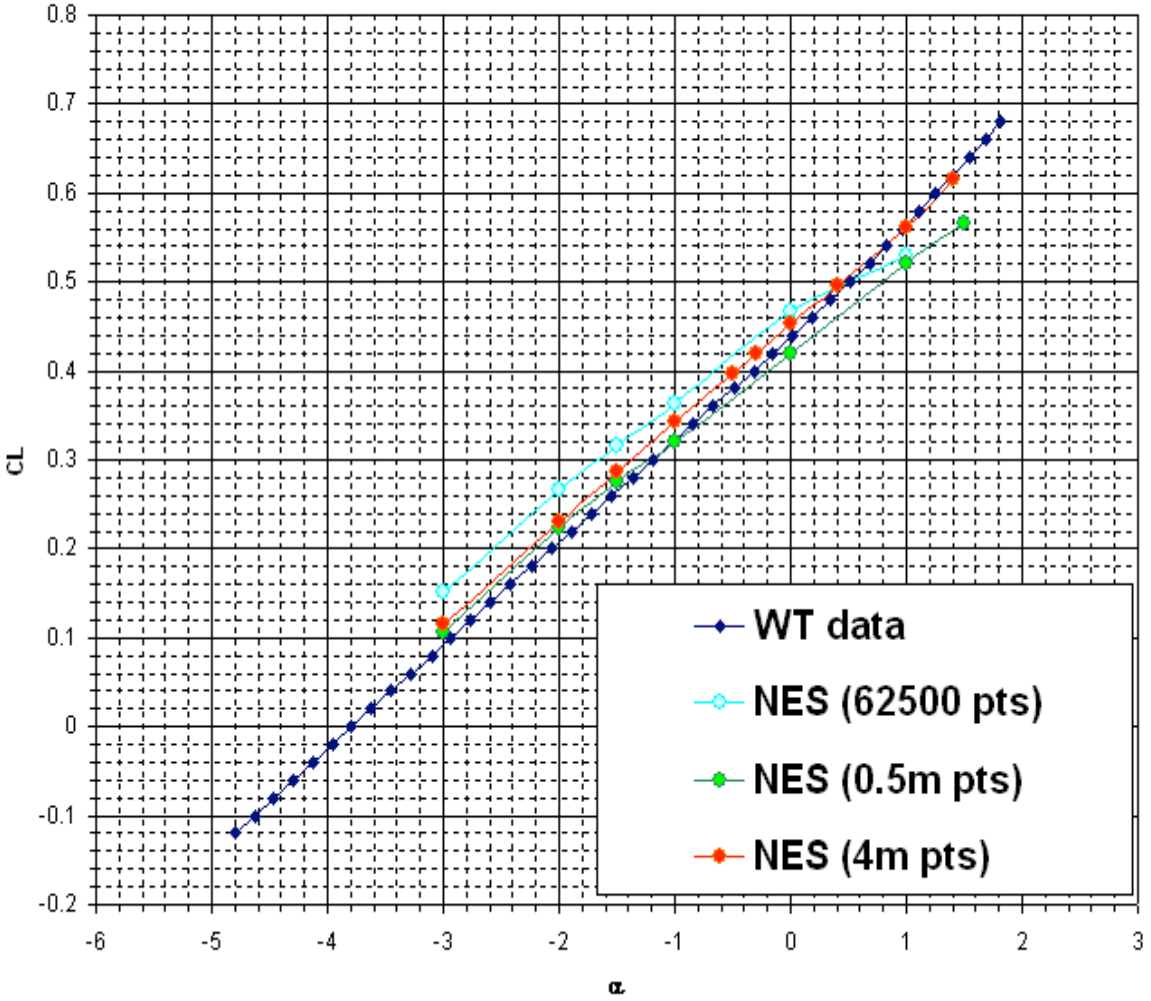




GRID CONVERGENCE

2nd AIAA DRAG PREDICTION WORKSHOP- JUNE 2003

LIFT VERSUS AoA - DLR_F6 (NACELLE OFF)



2nd AIAA DRAG PREDICTION WORKSHOP- JUNE 2003